Original Paper

Soil Pattern and Breeding of Sandfly in Endemic Areas of Bangladesh

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Abstract

Introduction: Sandfly breeds in soil but is selective to identify soil favourable for their breeding. Soil covered by vegetation, marshy land, orchards and settlements shows high sandfly breeding in an endemic region. Besides,the presence of inorganic constituents of the soil was found to affect sandfly breeding.

Objective: To identify soil pattern in Kala-azar endemic areas suitable for sandfly breeding, and the relationship of soil's physical and chemical properties with their breeding which may help in taking feasible measure to control the vector of Kala-azar or Visceral Leishmaniasis (VL).

Materials and Methods: The cross-sectional type of descriptive study was conducted in the Kala-azar endemic areas of Trishal and Fulbaria of Mymensingh, Madhupur of Tangail and Chatmohor of Pabna district, Bangladesh during the period of July 2015 to December 2015. From each site, 250 gm soil was collected and packed in a plastic container. All the samples were taken in the laboratory and were kept as it is for one week to configure the moisture and soil temperature maintaining the lab room temp at 28±2ºC and relative humidity at 75.0%±2.0. Soil samples were analysed for physical and chemical properties at the Soil Science Department of Sher-e-Bangla Agricultural University, Dhaka.

Results: Total 48 soil samples were collected from Trishal, Fulbaria, Madhupur, Chatmohor and each sample was analysed for physical property (sand, silt, clay, porosity, water content), chemical constituents (pH, C, N, Ca, Mg, K, P, Fe). The mean from each district's soil constituents (sand, silt, clay, porosity, water content) ranged from 17.36%-18.83%, 44.10%-45.46%, 35.70%-38.06% 41.98%-47.24% respectively and among the chemical constituents, pH ranged from 7.46-7.98, Carbon 0.92-0.98 $Cmolkg^{-1}$, Nitrogen 0.174-0.184 $Cmolkg^{-1}$, Calcium 4.83-6.21 $Cmolkg^{-1}$, Magnesium 1.97-2.46 $Cmolkg^{-1}$, Potassium as K_2O 1.37-1.79 $Cmolkg^{-1}$, Phosphorus as P_2O_5 12.60-13.78 $Cmolkg^{-1}$, Iron as Fe_2O_3 9.54-10.06 $Cmolkg^{-1}$ respectively.

Conclusion: Physical and chemical characteristics of soil by area of endemicity have been postulated to afford suitable environment for sandfly breeding. This information of the breeding sites of phlebotomine sandflies could help to plan environmental intervention measures that would impede the breeding of these insects.

Key–words: Soil pattern, Breeding, Sandfly, Endemic region, Visceral leishmaniasis, Bangladesh.

Introduction

Alluvial soil and high rainfall were believed to be the factors in the occurrence of foci of Kala-azar in India[1]. Based on this observation, several research reveals that VL is caused by an organism known as Leishmania donovani and this organism uses sandfly as a vector to complete its lifecycle. Sandfly chooses warmer climate for its breeding. So, Visceral leishmaniasis (VL) or Kala-azar is a vector-borne anthrozoonotic disease, endemic in warmer part of the world covering almost 88 countries; 16 developed and 72 developing countries around the globe with a total 350 million people at risk and 12 million cases of infection, of which 90% are reported in India, Bangladesh, Sudan, Nepal and Brazil[2]. Sandflies are tiny insects which can identify soil favourable for their breeding[3]. Larvae feed on dead organic

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matter; caves, cracks on the mud wall, floor, rocks, plinths, cracks on trees, under decaying leaves, animal burrows, cattle shed area are their choices of abode because these sites are suitable for larval development[4]. In the Indian subcontinent, *P. argentipesis* the only vector of Leishmania donovani[5]. It is seen that larva of *P. argentipes* is abundant in loose soil within 20 yards of human dwellings and cattle sheds[6]. In India, it has been detected frequently in soil samples in the earthen floor of human dwellings and cattle sheds[7]. It is also observed that alkaline soil of cattle sheds plays a vital role in amplifying the breeding potential of vector sandfly[8].

Kala-azar is a climate sensitive disease[9] basically due to the preferred breeding of sand fly vectors in alluvial soil with high subsoil water level, with temperatures ranging from 7 to 37ºC and relative humidity above 70%. Various ecological parameters i.e temperature, rainfall, wind speed, relative humidity, condition of soil (physical and chemical property) are known to influence the oviposition of female sandflies as well as their survival and development[5]. The area covered by vegetation including orchard, marshy land, and human colony increase their breeding potential. It is found in a study that, the pH of the soil in breeding locations of the endemic area is around 7.50-8.50. The same study reveals that the moisture content of the soil is about 12.20% higher than that in the non-endemic site[10]. Temperature from 20 to 24.9ºC had a highly significant effect on increasing the density of *P. argentipes*[10]. Amount of inorganic constituents of the soil also found to have a positive effect on sandfly breeding[11].

Phlebotomus argentipes has received much attention for their transmission of Leishmania donovani in mammals in Indian subcontinent. Shortage of information about breeding places of sandflies makes it difficult for taking appropriate control measures. A study has emphasized the importance of physicochemical properties of the soil in governing the breeding and distribution of sandflies[5].

The results obtained from this study are expected to have important implications, particularly on vector control strategies as well as management of risk factors associated with Visceral Leishmaniasis. This baseline information may help in altering any of the soil properties which can interfere with the breeding of sandfly. So, this study was conducted to identify soil pattern in Kala-azar endemic areas conducive to sandfly breeding and its relationship with physical and chemical properties of the soil; thus may help in taking measures in combating leishmaniasis.

Materials and Methods

The cross-sectional type of descriptive study was conducted in the Kala-azar endemic areas of Magurjora village of Trishal, Muchipara village of Fulbaria of Mymensingh, Madhupur of Tangail and Sardarpara of Saikola, Chatmohor of Pabna during the period of July 2015 to December 2015. These areas are plain and alluvial, dispersed with river, low marshy in nature and are well vegetated except few areas of Fulbaria and Madhupur which contain small mounds. The areas are well cultivable and economically important. Majority of the inhabitants live in poorly constructed mud houses and fence with adjoining cattle sheds and domestic birds pen surrounded by agricultural lands and vegetation. Aportion of people in the study area lives with domestic pet including cattle in same room. Soil samples were collected from those places where sandflies breed i.e damp places, corners and cracks, earthen plinth and floor of human houses and cattle sheds. Forty eight samples were collected from different sites and were taken from upper 2–3 inches of soil layer discarding the hard upper crusts. Soil from the cattle sheds was usually laden with cow dung and urine. From each site, 250 gm soil was packed in a plastic container. All the samples were taken in the laboratory and were kept as it is for one week maintaining room temp at 28±2ºC and relative humidity at 75.0%±2.00.

Soil samples were analyzed for physical and chemical properties in the Soil Science Department of Sher-e-Bangla Agricultural University, Dhaka. For physical property, the percentage of Sand, Silt, Clay, water content, Porosity and for chemical properties, pH, Fe, Ca, Mg, K, P, N were analyzed. Soil pH was measured with a digital pH meter (model HI–98107 Hanna Instruments, Romania Europe with the best accuracy of ±0.10 pH, range 0.0-14.0 pH). The collected soil samples were dissolved in distilled water with 1:1 ratio and pH meter was sunk for 5 minutes repeatedly 3 times for obtaining average pH value. All the other elements were measured and expressed in Cmol kg^{-1} (Centi mole per kg). Data regarding soil samples on physical and chemical properties were analysed statistically using SPSS version 20.

Results

Depending on the presence of Sand, Silt and Clay, all the samples (48) were classified by the physical characteristics are similar as Silty Clay Loam for all study places of Trishal, Fulbaria, Madhupur and Chatmohor (Table-I).

Table–I: Types of soil in study areas

Endemic area	Sand	Silt	Clay	Type of soil
Trishal	17.83%	44.10%	38.06%	Silty Clay Loam
Fulbaria	18.82%	45.35%	35.70%	Silty Clay loam
Madhupur	17.36%	44.57%	38.0 %	Silty Clay loam
Chatmohor	18.13%	45.46%	36.39%	Silty Clay Loam

Table–II described the porosity of the soil samples as 42.81%±0.395, 41.98%±0.114, 42.83%±0.128, 47.24%±0.375 at the soil of Trishal, Fulbaria, Madhupur and Chatmohor. The water contents were 6.50–14.90 % in Human dwelling and 10.50–15.2% in Cattle sheds in the soil samples of Trishal. Soil samples of Fulbaria contained water as 7.60–13.90% in human dwellings and 10.20–14.00% in cattle sheds. In Madhupur the water contents of soils were 8.50–14.50% in human dwellings and 11.00–15.00% in cattle sheds. Human dwellings soils of Chatmohor contain water as 7.50–13.90% and cattle sheds soil contain 10.00-14.80%.

Table–II: Distribution of physical properties of soil of study area

Endemic area	Sand (%)	Silt (%)	Clay (%)	Porosity (%)	Water contents (%)
Trishal	17.20 – 18.50 (17.83 ± 0.426)	43.30 – 44.50 (44.10 ± 0 .439)	37.0 – 39.00 (38.06 ± 0.687)	42.39 – 43.40 (42.81 ± 0.395)	6.50 – 14.70 HD 10.50 – 15.20 CS
Fulbaria	18.31 – 19.41 (18.82 ± 0.306)	44.15 – 46.25 (44.35 ± 0.718)	35.00 – 36.85 (35.70 ± 0.585)	41.85 – 42.20 (41.98 ± 0.114)	7.60 – 13.90 HD 10.20 – 14.00 CS
Madhupur	16.75 – 17.90 (17.36 ± 0.518)	43.77 – 45.80 (44.57 ± 0.787)	37.45 – 38.50 (38.06 ± 0.448)	42.67 – 43.00 (42.83 ± 0.128)	8.50 – 14.50 HD 11.00 – 15.00 CS
Chatmohor	17.75 – 19.00 (18.13 ± 0 .527)	44.90 – 45.80 (45.46 ± 0.353)	35.44 – 37.10 (36.39 ±0.629)	46.80 – 47.69 (47.24 ± 0.375)	7.50 – 13.90 HD 10.00 – 14.80 CS

Table–III shows that pH of the study area varied within 6.50–8.90. The other constituents of the soil like C, N, Ca, Mg, K, P, Fe varied from 0.78–1.01 Cmol kg^{-1}, 0.10–0.26 Cmol kg^{-1}, 3.42–9.80 Cmol kg^{-1}, 1.07–3.50 Cmol kg^{-1}, 0.69–2.50 Cmol kg^{-1}, 9.87–15.39 Cmol kg^{-1}, 8.45–10.65 Cmol kg^{-1} respectively.

Table–III: Distribution of chemical properties of soil of study area

Endemic area	pH	C Cmol kg^{-1}	N Cmol kg^{-1}	Ca Cmol kg^{-1}	Mg Cmol kg^{-1}	K_2O Cmol kg^{-1}	P_2O_5 Cmol kg^{-1}	Fe_2O_3 Cmol kg^{-1}
Trishal	6.900 – 8.900 7.980 ± 0.561	0.780 – 1.0100 0.924 ± 0.0690	0.100 – 0.250 0.174 ± 0.052	3.42 – 8.850 5.06 ± 1.723	1.45 – 3.160 2.31 ± 0.625	1.12 – 2.500 1.79 ± 0.444	10.50 – 14.60 12.60 ± 1.273	8.90 – 10.65 10.06 ± 0.493
Fulbaria	6.500 – 8.500 7.460 ± 0.625	0.890 – 1.0000 0.960 ± 0.0388	0.120 – 0.250 0.184 ± 0.052	3.42 – 8.850 4.83 ± 1.536	1.45 – 3.160 2.31 ± 0.625	0.95 – 2.500 1.60 ± 0.425	11.10 – 14.47 13.14 ± 1.219	8.90 – 10.70 9.87 ± 0.640
Madhupur	7.200 – 8.600 7.920 ± 0.432	0.890 – 1.0000 0.960 ± 0.0388	0.120 – 0.250 0.180 ± 0.052	3.42 – 8.800 4.83 ± 1.707	1.45 – 3.500 2.46 ± 0.624	0.79 – 2.200 1.37 ± 0.501	10.45 – 14.50 13.03 ± 1.339	8.45 – 10.50 9.54 ± 0.663
Chatmohor	6.800 – 8.880 7.760 ± 0.634	0.960 – 1.0100 0.980 ± 0.0159	0.100 – 0.260 0.183 ± 0.521	3.52 – 9.800 6.21 ± 1.919	1.07 – 2.900 1.97 ± 0.619	0.69 – 2.350 1.50 ± 0.586	9.87 – 15.39 13.78 ± 01.84	8.65 – 10.60 9.74 ± 0.682

Discussion

Soil is the important substratum for sandfly breeding and they prefer the vicinity of human and animals living area having houses of human and cattle sheds made up of mud i.e. plinth, wall, plaster, house fence/wall, floor, pen of domestic fowls, sides of ponds, sides of rivers canals etc. Of course, it depends upon the quality, type of soil and constituents present in it. In this study, the larval presence or growth and Soil Productivity Rate (SPR) for sandfly breeding has not been observed from the soil samples; but since the study areas are known endemic zone of breeding sites of sandflies, so this study observed the physical and chemical properties of the soil samples only.

In this study, after having the percentages of sand, silt and clay from the soil samples of the study areas, they were typed as Silty Clay Loam (Table–I) which is similar to the findings of Islam MT et al[12]. Moncaz A et al found soil types of sandfly breeding areas were either sandy clay loam or sandy loam or clay loam[13].

Sivabnaname and Amalraj gave emphasis on the physical and chemical properties of the soil of the area of breeding[5]. Asbreeding of sandfly is governed by physical and chemical properties of soil, so it is well understood that similar constituents will be present in different proportions in soil of distribution area of sandfly[5]. In this study, ranges of sand, silt, clay content of soil samples were 17.20%-19.41%, 43.30%-46.25% and 35.0%-39.0% respectively (Table–II). In Kesari S et al, the Soil productivity Rate (SPR) for *P. argenitpes* was having a positive correlation with soil properties where sand was 48.61-50%. 65%, Silt was 30.28-33.40% and clay was 17.99-19.57%[7]. So the sand, silt and clay contents in this study samples are favourable for sandfly breeding. Porosity and water contents of soil are also important for sandfly breeding[14]. This study found the range of porosity of soil samples was 41.85%-47.69%. Similarly, water content varied from 6.50 -14.90% and 10.00-15.20% for soil samples collected from human dwellings and cattle sheds respectively (Table–II). Sand flies, unlike mosquitoes, do not breed in water and there is relatively little information on their breeding sites[3].

Kesari et al found the porosity and water content 46.36-47.93% and 9.83-12.30% respectively in his study and showed that SPR for sandfly was positively correlated with the above-mentioned range[7]. The findings of this study are similar to that of Kesari et al. Porosity of soil found in Mojid MA et al was 43-52% in different samples of soil[15]. The water content of soil samples in Islam MT et al was found 15.50-19.00%[12]. The findings of this study are also consistent with sandfly breeding.

The soil pH of the study area ranged from 6.50-8.90. The pH of cattle sheds was found higher in the soil samples of cattle sheds 8.90 (Table–III). In Kesari et al, soil pH was found 7.19-8.12 and was positively correlated with sandfly productivity which is consistent with the findings of this study[7]. Singh R et al[8] found the pH of the soil of the breeding places of cattle sheds 6.00-9.10 and that of human habitats 6.00-7.80. A significant correlation was found with SPR for *P. Argentipes* with alkaline pH of soil.

In soil, organic carbon tends to be concentrated in the topsoil. Topsoil ranges from 0.5% to 3.0% organic C for most upland soils. Soils with less than 0.5% organic C is mostly limited to desert areas. Soils containing greater than 12-18% organic C is generally classified as organic soils. High levels of organic C develop in soils supporting wetland ecology, flood deposition, fire ecology and human activity[16]. The area from where the soil samples were collected had the characteristics of wetland ecology, flood deposition and human activity and soil of this area may contain high level of organic Carbon. The available Carbon contents of the soil samples ranged between 0.78-1.01 $Cmolkg^{-1}$ (Table–III). This level of Carbon content may positively influence breeding of sandfly.

The available Nitrogen contents of the soil samples ranged between 0.10-0.26 $Cmolkg^{-1}$ (Table–III). In Morshed RM[17], the soil content of Nitrogen varied between 0.26-0.70 $CmolKg^{-1}$. Morshed RM found that the Nitrogen content of the soil was varied from 0.02-0.14 $CmolKg^{-1}$ in his study[17].

In India, the presence of inorganic constituents in the soil was found as characteristics of the breeding sites of sandflies[18]. In this study, Calcium (Ca), Magnesium(Mg), Potassium (K), Phosphorus (P) and Iron (Fe) contents of the soil samples ranged from 3.42-9.80 CmolKg-1, 1.07-3.50 CmolKg-1, 0.69-2.50 CmolKg-1, 9.87-15.39 CmolKg-1 and 8.45-10.70 CmolKg-1 respectively which was favourable for sandfly breeding.

Shreekant K et al found the soil contents of Ca, Mg, K, P, Fe was on an average 5.89, 3.13, 2.04, 0.05, 9.14 $CmolKg^{-1}$ in endemic area and in the non-endemic area it was 1.27, 0.57, 1.81, 2.68, 12.74 $CmolKg^{-1}$ respectively. Results indicate that these contents are higher in endemic area than in non-endemic region. And the findings were correlated with Soil Productivity Rate for sandfly breeding[18]. In Kesari S et al the soil contents of N, Ca, Mg, K, P, I were 0.16, 6.77, 3.29, 2.19, 0.38, and 9.69 $CmolKg^{-1}$ respectively and the results of the analysis showed SPR for *P. argentipes* had a positive correlation with the soil properties[7].

The distribution and abundance of sandflies depend on physical properties and chemical constituents of the soil. After analysing the results of this study and observing the interpretations of other related studies (used as references), it is seen that variation and similarity exist between different physical properties and chemical constituents of the soil of different study areas.

Conclusion

In this study, Silty Clay Loam soil was recorded from all the samples that provide stable temperature, high humidity and decaying organic matter and all of these factors favour the reproduction of sandflies. Physical and chemical characteristics of soil by area of endemicity have been postulated to afford suitable environment for sand fly breeding. This Knowledge of the breeding sites of *P. Argentipes* could help orient environmental intervention measures that would impede the breeding of these insects and justify the application of preventive measures to control transmission.

Acknowledgement

The authors acknowledge the contribution, co-operation and labour they gave to this study works and field site activities of Dr Anup, Dr Nasreen of AFMC, Dhaka Cantonment; Md. Shahidul Islam, Sanitary Inspector, Upazilla Health Complex, Chatmohor, Pabna; Mr Abdur Razzak, Veterinary Field Asst of Fulbaria Live Stock Office. Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka and Department of Microbiology and Hygiene, Bangladesh Agricultural University, Mymensingh.

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